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ABSTRACT

The effectiveness of multiple matrix sampling was examined in a study of 495 students' attitudes toward a computer education program. A post hoc analysis of variance was used, with the class as the unit of analysis. The Computer Attitude Scale, a 30-item rating scale, was used to measure attitudes toward learning about and working with computers. The amount of computer experience was also obtained: less than one month, one to six months, or over six months. Results indicated that: (1) increasing amounts of computer experience were associated with more positive attitudes toward computers; (2) means obtained by multiple matrix sampling generally estimated actual means satisfactorily; (3) the same conclusions were drawn from using the estimated means in a one way analysis of variance as were drawn from using population values; and (4) power of the analysis was affected by the class size. (Author/GDC)

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Investigation of Multiple Matrix Sampling for Attitude Data Analysis

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Investigation of Multiple Matrix Sampling for Attitude Data Analysis

Multiple matrix sampling is a technique for estimating parameters based on a series of subtests in which randomly selected examinees take subtests composed of randomly selected items. This study used a post hoc analysis to investigate the effectiveness of using multiple matrix sampling for attitude data analysis, specifically when class is used as the unit of analysis. Results indicated 1) means obtained by multiple matrix sampling generally estimated actual means satisfactorily; 2) the same conclusions were drawn from using the estimated means in a oneway analysis of variance procedure as were drawn using population values; and 3) power of the analysis was affected by class size.

An Investigation of Multiple Matrix Sampling for Attitude Data Analysis

Often in the field of educational evaluation and research, survey studies are conducted. These studies may involve an unusually large number of subjects and instruments which are comprised of numerous items. These studies can become costly in time, money and subjects. Validity may also become a concern with such studies, since with long surveys there is often the possibility of erratic or incomplete responses due to fatigue or boredom. Specifically, for younger subjects such as those in elementary or middle school, the number of items which may be administered validly is often small because of short attention spans.

Multiple matrix sampling is a technique for estimating test parameters based on a series of subtests in which randomly selected examinees take subtests composed of randomly selected items. Total test scores are developed based on data in which no examinee has taken all items. Studies (Lord, 1962; Plumlee, 1964) have demonstrated the effectiveness of multiple matrix sampling in estimating population parameters such as the mean and variance. Most studies have supported the parity or superiority of multiple matrix sampling as compared to examinee sampling for estimating mean and variance of achievement data. More recently, studies have successfully applied multiple matrix sampling to the estimation of parameters for attitude scales including Likert (Pugh, 1971; Umila, 1982), paired comparison (Shoemaker, 1971;

Olson, 1978), and rank order (Askegaard and Umila, 1982; Askegaard, 1983) scales.

The applicability of multiple matrix sampling to attitude data analysis at first may be perceived as limited. The procedure has most often been used when an estimate of a parameter such as the mean or standard deviation was desired. Little research has yet been devoted to the applicability of using the information derived from multiple matrix sampling in such analyses as hypothesis testing. The purpose of this study is to determine the applicability of multiple matrix sampling in analyzing differences among groups in a oneway analysis of variance. Specifically, this study investigated the use of multiple matrix sampling as a strategy for collecting data to describe computer attitudes and to perform a three level oneway analysis of variance procedure where the dependent measure was the computer attitude score obtained with a Likert-type instrument. In addition, the study investigates the effect of different multiple matrix sampling plans on the power of the oneway ANOVA.

Method

Design and Procedures

The present study used a post-hoc analysis of computer attitude data which was obtained through the evaluation of a computer education program presented to 495 students in two school systems in Virginia. The students were administered the Computer Attitude Scale (Loyd and Gressard, 1984), a 30 item

Likert type instrument which measures attitudes toward learning about and working with computers. Students respond to the positively and negatively worded items by selecting one of four responses ranging from "strongly agree" to "strongly disagree." Cronbach's alpha coefficient calculated for the Computer Attitude Scale was .93.

Information on the amount of computer experience of each student was also obtained. Three levels of computer experience (less than one month, one month to six months, more than six months) formed the three levels of the independent variable, amount of computer experience. Using all 495 students in a oneway analysis of variance the means of the 3 levels of computer experience were statistically different. The means of each of the 3 levels of computer experience based on the entire group of 495 students became the population values for the multiple matrix comparisons.

In multiple matrix sampling only partial (subtest) information is obtained for any individual. To perform an analysis of variance, a class is formed by taking the mean of the individual subtest scores within the class. The class is then used as the unit of analysis. To create the "classes" students were first categorized by their level of computer experience and then randomly assigned to a "class." For the first comparison, a class size of 3 was established. Thus, random groups of 3 students were formed which created a total of 90 classes for the

first level of computer experience; 30 classes for the second level of computer experience; and 45 classes for the third level of computer experience. For the second comparison, a class size of 9 was established. Thus, random groups of 9 students were formed which created a total of 30 classes for the first level of computer experience; 10 classes for the second level of computer experience; and 15 classes for the third level of computer experience. For the third comparison, a class size of 15 students was used creating a total of 18 classes for the first level of computer experience; 6 classes for the second level of computer experience; and 9 classes for the third level of computer experience. For the fourth comparison a class size of 45 was used creating a total of 6 classes for the first level of computer experience, 2 classes for the second level of computer experience, and 3 classes for the third level of computer experience.

To determine the individual class means by multiple matrix sampling, the following steps were implemented:

1. Using simple random sampling without replacement, the 30 computer attitude items were divided into three subtests, each with 10 items.
2. The subtests were randomly matched with the subgroups of students from each class to form a single exhaustive, non-overlapping, 3/10/n item-examinee design where the first number indicates number of subtests (3), the second number indicates number of

items on the subtest 10), and "n" indicates the number of students administered each subtest per class. For example, in the analyses which used class size of 3, the item-examinee design was 3/10/1.

3. The mean of each subtest matrix was computed and pooled to obtain an estimate of the mean which would have been obtained had the students in the class responded to all the items in the scale.

Steps 1 through 3 were carried out for each of the 4 class sizes.

Analysis

First, the accuracy of the multiple matrix procedures in estimating the individual class means of the three levels of computer experience was examined. Since this was a post hoc study population values are assumed to be known. The means obtained by multiple matirx sampling were considered estimates of these population values. Therefore, to determine the accuracy of the estimates, three one sample t-test procedures, corresponding to the three levels of computer experience were performed. These three t-test procedures were repeated four times, once for each of the four class sizes.

Second, to examine the effect of multiple matrix sampling on hypothesis testing, the means obtained by multiple matrix sampling were used in a oneway analysis of variance procedure. The oneway ANOVA procedure was repeated for each of the four class sizes.

For each ANOVA procedure the three levels of computer experience formed the independent variable, computer attitude was the dependent variable, and class mean was the unit of analysis.

Third, to examine the effect of different class sizes upon an analysis of variance procedure, a phi coefficient, which is directly related to power (Winer, 1971), was calculated for each of the oneway analysis of variance procedures performed. The phi coefficients were compared with a higher value indicating more power. Phi, ϕ is calculated as follows:

$$\phi = \sqrt{\frac{\Sigma nj(\mu j - \mu)^2}{a\sigma_\varepsilon^2}}$$

where μj is the mean for each level of computer experience based on the population of 495 students,

μ is the grand mean of computer experience,

a is the number of treatments (3)

nj is the number of units of analysis in level j, and

σ_ε^2 is the error within which is estimated by the MS within term for the ANOVA procedure.

Results

The population means and standard deviations of computer attitudes for the three levels of computer experience are presented in Table 1. The mean for the first level of computer experience was 91.87 with a standard deviation of 15.71. The mean for the second level of computer experience was 96.51 with a standard deviation of 15.65. The mean for the third level of computer experience was 105.78 with a standard deviation of

12.93.

The means and standard deviations of computer attitudes for the three levels of computer experience obtained by multiple matrix sampling for the class size of 3 are also presented in Table 1. The mean for the first level of computer experience was 91.97 with a standard deviation of 9.07. The mean for the second level of computer experience was 96.37 with a standard deviation of 8.13. The mean for the third level of computer experience was 104.82 with a standard deviaiton of 8.66. For all three levels of computer experience results of the one sample t-test indicated that there was not a statistically significant difference between the estimated group means and the population values at the .05 alpha level. The results suggest that when "class" is formed by the multiple matrix sampling design 3/10/3, population means are satisfactorily estimated.

The means and standard deviations of computer attitudes for the three levels of computer experience obtained by multiple matrix sampling for the class size of 9 are also presented in Table 1. The mean for the first level of computer experience was 92.23 with a standard deviation of 4.93. The mean for the second level of computer experience was 96.87 with a standard deviation of 6.78. The mean for the third level of computer experience was 105.60 with a standard deviation of 5.08. For all three levels of computer experience results of the one sample t-test indicated that there was no statistically significant difference between the estimated group means and the population values at the .05

alpha level. The results suggest that when "class" is formed by the multiple matrix sampling design 3/10/3, population means are satisfactorily estimated.

The means and standard deviations of computer attitudes for the three levels of computer experience obtained by multiple matrix sampling for the class size of 15 also presented in Table 1. The mean for the first level of computer experience was 92.07 with a standard deviation of 2.91. The mean for the second level of computer experience was 96.60 with a standard deviation of 4.82. The mean for the third level of computer experience was 105.53 with a standard deviation of 4.00. For all three levels of computer experience results of the one sample t-test indicated that there was no statistically significant difference between the estimated group means and the population values at the .05 alpha level. The results suggest that when "class" is formed by the multiple matrix sampling design 3/10/5, population means are satisfactorily estimated.

The means and standard deviations of computer attitudes for the three levels of computer experience obtained by multiple matrix sampling for the class size of 45 are also presented in Table 1. The mean for the first level of computer experience was 91.92 with a standard deviation of 2.43. The mean for the second level of computer experience was 96.39 with a standard deviation of 3.16. The mean for the third level of computer experience was 104.82 with a standard deviation of 3.18. For all three levels of computer experience results of the one sample t-test

procedures indicated that there was no significant difference between the estimated group means and the population values. The results suggest that when "class" is formed by the multiple matrix design 3/10/15, population means are satisfactorily estimated.

The results of the oneway analysis of variance procedure of the original population using computer experience as the independent variable and computer attitude as the dependent variable are presented in Table 2. The difference in level means was found to be statistically significant ($F=38.71$, $df=(2,492)$, $p<.05$). Follow-up procedures indicated that students with computer experience of less than one month had significantly less positive computer attitudes than students with computer experience of one month to six months and those students had significantly less positive attitudes than students with computer experience of more than six months.

The results of the oneway analysis of variance procedure using computer experience as the independent variable and computer attitude as the dependent variable for a class size of 3 are presented in Table 3. The difference in group means was found to be statistically significant ($F=26.52$, $df=(2,162)$, $p<.05$). Follow-up procedures indicated that students with computer experience of less than one month had significantly less positive computer attitudes than students with one month to six months experience and those students had significantly less

positive attitudes than students with computer experience of more than six months.

The results of the oneway analysis of variance procedure using computer experience as the independent variable and computer attitude as the dependent variable for a class size of 9 are presented in Table 4. The difference in group means was found to be statistically significant ($F=31.42$, $df=(2,52)$, $p<.05$). Follow-up procedures indicated that students with computer experience of less than one month had significantly less positive computer attitudes than students with one month to six months experience and those students had significantly less positive attitudes than students with more than six months computer experience.

The results of the oneway analysis of variance procedure using computer experience as the independent variable and computer attitude as the dependent variable distributed as a class size of 15 are presented in Table 5. The difference in group means was found to be statistically significant ($F=42.09$, $df=(2,30)$, $p<.05$). Follow-up procedures indicated that students with less than one month computer experience had significantly less positive computer attitudes than students with one month to six months experience and those students had significantly less positive attitudes than students with more than six months experience.

The results of the oneway analysis of variance procedure using computer experience as the independent variable and

computer attitude as the dependent variable for a class size of 45 are presented in Table 6. The difference in group means was found to be statistically significant ($F=22.20$, $df=(2,8)$, $p<.05$). Follow-up procedures indicated that students with less than one month computer experience had significantly less positive computer attitudes than students with one month to six months experience and those students had significantly less positive attitudes than students with more than six months experience.

In each repetition of the oneway analysis of variance procedures using computer experience as the independent variable and computer attitude as the dependent variable, the statistical conclusion to reject the null hypothesis of no difference between group means was drawn. For each repetition, follow-up procedures indicated a statistical difference between the means of each level of computer experience. The results susggest that the application of multiple matrix sampling to a oneway analysis of variance procedure satisfactorily replicated the results derived from the same procedure in which individual total scores of all examinees were used as the unit of analysis.

The phi coefficients calculated for each oneway analysis of variance procedure are presented in Table 7. The phi calculated for the oneway ANOVA in which individual scores were used as the unit of analysis was 5.08. The phi coefficients calculated for the oneway ANOVA procedures when class means were used as the unit of analysis were 4.55, 4.76, 5.47, and 4.16 for the class size of 3, 9, 15, and 45, respectively. The results show that

phi increases from a class size of 3 to a class size of 9 to a class size of 15. However, phi decreases dramatically as class size increased from 15 to 45. The results also show that the phi calculated for the class sizes of 3, 9, and 45 is less than the phi of 5.08 calculated for the population of 495 students. However, for class size of 15, phi (and, therefore, power) is greater than that for the population of 495 students.

Discussion

The purpose of this study was to determine the applicability of multiple matrix sampling in analyzing differences among groups in a oneway analysis of variance procedure. The results of the three one sample t-tests, corresponding to the three levels of computer experience, which were repeated for each class size indicated that individual class means and group means were satisfactorily estimated by multiple matrix sampling. These results support findings of other studies (Pugh, 1971; Umila, 1982) in which multiple matrix sampling was applied to scores obtained with a Likert-type instrument.

The results of the four oneway ANOVAs using class as a unit of analysis demonstrate a satisfactory application of multiple matrix sampling to hypothesis testing using attitude data. Conclusions drawn from both the oneway analysis of variance procedures and the follow-up procedures were the same using individual attitude scores or the various class sizes created by multile matrix sampling as the unit of analysis.

In this study a phi coefficient was calculated for each oneway analysis of variance procedure performed. Since effect size and alpha level remained constant for each calculation the results suggest that an increase in power seems to be gained with an increase in class size at least up to the class size of 15. Although it is not clear from this study where the point of diminishing returns occurs, it may be assumed that when the number of units (number of classes) has decreased beyond a certain point, power is diminished and this lessening of power is not compensated for by the decrease in variablility within groups. The results of the study suggest that multiple matrix sampling is a viable option for designs involving hypothesis testing and somewhat surprisingly suggests that some multiple matrix sampling designs may be more powerful than traditional sampling designs.

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Table 1

Means and Standard Deviations of the Three Levels of Computer Experience by Class Size

	Computer Experience					
	Less Than 1 Month		1 Month To 6 Months		More Than 6 Months	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Class 3 (3/10/1)	91.97	9.07	96.37	8.13	104.82	8.66
Class 9 (3/10/3)	92.23	4.93	96.87	6.78	105.60	5.08
Class 15 (3/10/5)	92.07	2.91	96.60	4.82	105.53	4.00
Class 45 (3/10/15)	91.97	2.43	96.37	3.16	104.82	3.18
Population Values	91.87	15.71	96.51	15.65	105.78	12.93

Table 2

Summary Table for Oneway ANOVA Using Individual Scores as the Unit of Analysis

Source	df	MS	F
Between groups	2	8703.72	38.71*
Within groups	492	224.84	

*p<.05

Table 3

Summary Table for Oneway ANOVA Using Class Size of Three as the Unit of Analysis

Source	df	MS	F
Between groups	2	2479.14	26.52*
Within groups	162	93.50	

*p<.05

Table 4

Summary Table for Oneay ANOVA Using Class Size of Nine as the Unit of Analysis

Source	df	MS	F
Between groups	2	893.47	31.42*
Within groups	52	28.44	

*p<.05

Table 5

Summary Table for Oneway ANOVA using Class Size of Fifteen as the Unit of Analysis

Source	df	MS	F
Between groups	2	544.06	42.09*
Within groups	30	12.93	

*p<.05

Table 6

Summary Table for Oneway ANOVA Using Class Size of Forty-five as the Unit of Analysis

Source	df	MS	F
Between groups	2	165.30	22.20*
Within groups	8	7.45	

*p<.05

Table 7

Phi Coefficients Calculated for Oneway ANOVA Procedures

Units of Analysis	
Individual Scores	5.08
Multiple Matrix Sampling	
Class Size of 3	4.55
Class Size of 9	4.76
Class Size of 15	5.47
Class Size of 45	4.16